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RESULTS OF FIELD APPLICATIONS OF HERBICIDES  
FOR CONTROL OF SALT CEDAR (TAMARIX SPP.)

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Agricultural Research Service,  
U. S. DEPARTMENT OF AGRICULTURE

## CONTENTS

	Page
Introduction . . . . .	3
Methods . . . . .	3
Detailed procedures, results and discussion . . . . .	6
Ground-applied foliage spray herbicides . . . . .	6
Ground application of granular and soil spray herbicides . .	9
Aerial application of foliage spray herbicides . . . . .	11
Summary . . . . .	14

### CAUTION

The control of saltcedar and other phreatophytes with herbicides in river channels and on ditchbanks of irrigation systems must be done with care. Use only materials registered for use under these conditions. The end use of the water must be considered to prevent contamination of public water supplies, wildlife areas, recreation areas, and irrigation uses.

RESULTS OF FIELD APPLICATIONS OF HERBICIDES  
FOR CONTROL OF SALT CEDAR (TAMARIX SPP.)<sup>1/</sup>

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INTRODUCTION

The cooperative research project on control of phreatophytes was initiated in 1961. Although the laboratory, greenhouse, and office are located on the Middle Rio Grande Branch Station, Los Lunas, N. Mex., all of the small plot field work is being done near Bernardo, N. Mex. Aerial plots are in Arizona, Kansas, Oklahoma, and Texas. Several species of plants are classified as phreatophytes, but saltcedar is the most resistant to control and is rapidly spreading throughout the West in river channels and on ditchbanks of irrigation systems.<sup>3/</sup>

The limited research information available on chemical control of saltcedar<sup>4/</sup> with 2,4-D, 2,4,5-T, and silvex had shown that the same herbicide may react differently under different conditions. For this reason, an ester of silvex that had given good control as a foliage spray in Arizona<sup>4/</sup> was used as a standard for comparison. Initial research was devoted to field evaluation of herbicides that were known to have an effect on other woody plants, as well as some herbicides that had not been tested. Research reported here was carried out from 1961 to 1963.

METHODS

For most ground applications of foliage spray herbicides, the plot size was 24 x 90.75 feet, or 0.05 acre. For ground applications of granular, soil spray, and some foliage spray herbicides, plot size was a rod square. All 0.05-acre plots were sprayed with a 12-foot boom, one side at a time, at 20-p.s.i. pressure, using 6502 nozzle orifices. Unless specified otherwise, all ground applications of foliage herbicides were sprayed at a volume of 20 gallons per acre. Standard rates of 2 and 4 pounds acid equivalent per acre (ae/acre) were used in most cases.

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<sup>1/</sup> Cooperative investigations of the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the New Mexico Agricultural Experiment Station.

<sup>2/</sup> Range Conservationist, Crops Research Division, Agricultural Research Service.

<sup>3/</sup> Thompson, C. B. Importance of phreatophytes in water supply. Paper given at Intersociety Conference on Irrigation and Drainage. 16 pp. 1957. [Processed.]

<sup>4/</sup> Timmons, F. L. Research in the control of phreatophytes. Paper presented at the Soil Conservation Service Hydraulic Engineers Meeting, New York, N.Y., August 12-16, 1963.

<sup>5/</sup> Arle, H. Fred. Saltcedar control with chemicals. Remarks given at Western Weed Conference. 4 pp. 1959. [Processed.]

Granular and soil spray herbicide plots were treated by distributing the granules or spray evenly over the 1-rod-square plots, with a buffer zone of 10 feet between plots. Soil spray herbicides were applied at a volume of 300 gallons of water per acre. Standard rates of 5 and 20 pounds active ingredient per acre (ai/acre) were used for granular and soil spray herbicides.

For aerial applications of foliage spray herbicides, plot size was 1,178 x 72 feet, or 2 acres. Both helicopter and fixed-wing aircraft were used. Unless otherwise specified, all aerial applications of herbicides were applied at a volume of 10 gallons per acre.

All ground applications of foliage spray, soil spray, and granular herbicides were replicated three times. Because of the cost, only one plot was used for each treatment. The aerial plots were evaluated by taking five 50-foot (estimated) radius samples per plot and recording dead and live plants. All other plots were evaluated, using a 4.2- x 4.2-foot frame. Two random samples were taken in the 1-rod-square plots and four in the 0.05-acre plots.

The common or trade and complete chemical names of all herbicides evaluated and sources of the test samples are listed in table 1.<sup>6/</sup>

<sup>6/</sup> Trade names are used in this publication solely to provide specific information. Mention of a trade name or a manufacturer's name does not constitute a guarantee or warranty and does not signify that the products or the manufacturer is approved to the exclusion of other comparable products or manufacturers.

TABLE 1.--Common or trade and complete chemical names and sources of herbicides tested

Common or trade name	Complete chemical name	Source
atratone-----	2-methoxy-4-ethylamino-6-isopropyl-amino-s-triazine	Geigy Chemical Corp.
Benzac 354-----	mixture of tetrachloro, trichloro, and polychloro benzoic acids	Amchem Products, Inc.
bromacil-----	5-bromo-3-sec-butyl-6-methyluracil	E. I. du Pont de Nemours & Co. (Inc.)
Brushkiller 977-----	2,4-D + 2,4,5-T BE ester (ratio 2/3:1/3)	Amchem Products, Inc.
2,4-D-----	2,4-dichlorophenoxyacetic acid	-----
2,4-D + 2,4,5-T (50:50)	oil-soluble amine of 2,4-D + 2,4,5-T (50:50)	Amchem Products, Inc.
PGBE ester of 2,4-D + 2,4,5-T (50:50).	propylene glycol butyl ether ester of 2,4-D + 2,4,5-T (50:50)	Dow Chemical Co.
amine salt of 2,4-D + 2,4,5-T (50:50).	triethyl amine salt of 2,4-D + 2,4,5-T (50:50)	Stull Chemical Co.
dicamba-----	2-methoxy-3,6-dichlorobenzoic acid	Velsicol Chemical Corp.

TABLE 1.--Common or trade and complete chemical names and sources of herbicides tested--Continued

Common or trade name	Complete chemical name	Source
dichlorprop-----	2-(2,4-dichlorophenoxy)propionic acid	-----
EA of dichlorprop---	emulsifiable acid of 2,4-DP	Amchem Products, Inc.
IO ester of	isooctyl ester of 2,4-DP	Hercules Powder Co.
dichlorprop.		
OS amine of	oil-soluble amine of 2,4-DP	Do.
dichlorprop.		
diuron + WK-----	3-(3,4-dichlorophenyl)-1,1-dimethylurea + dodecyl ether of polyethylene glycol	E. I. du Pont de Nemours & Co. (Inc.)
fenac-----	2,3,6-trichlorophenylacetic acid	Amchem Products, Inc.
fenuron-----	3-phenyl-1,1-dimethylurea	E. I. du Pont de Nemours & Co. (Inc.)
Glytac-----	ethylene glycol bis (trichloroacetate)	Hooker Chemical Corp.
isocil-----	5-bromo-3-isopropyl-6-methyluracil	E. I. du Pont de Nemours & Co. (Inc.)
monuron-----	3-(p-chlorophenyl)-1,1-dimethylurea	Do.
picloram-----	4-amino-3,5,6-trichloropicolinic acid	Dow Chemical Co.
prometone-----	2-methoxy-4,6-bis(isopropylamino)-s-triazine	Geigy Chemical Corp.
silvex-----	2-(2,4,5-trichlorophenoxy)propionic acid	-----
BE ester of silvex--	butoxyethanol ester of silvex	Amchem Products, Inc.
EA of silvex-----	emulsifiable acid of silvex	Do.
IO ester of silvex--	isooctyl ester of silvex	Hercules Powder Co.
OS amine of silvex--	oil-soluble amine of silvex	Amchem Products, Inc.
PGBE ester of silvex	propylene glycol butyl ether ester of silvex	Dow Chemical Co.
2,4,5-T-----	2,4,5-trichlorophenoxyacetic acid	-----
2,3,6-TBA-----	2,3,6-trichlorobenzoic acid	Amchem Products, Inc.
Tritac-----	2,3,6-trichlorobenzoyloxypropanol	Hooker Chemical Corp.
X-77-----	alkylaryl polyoxyethelene glycol in isopropanol	Colloidal Products Corp.
62-255-----	2,4-D + 2,4,5-T + fenac (.50:.125:.375)	Amchem Products, Inc.
62-256-----	2,4-D + 2,4,5-T + fenac (.33:.33:.66)	Do.
62-257-----	2,4-D + 2,4,5-T + fenac (.25:.25:.50)	Do.
62-258-----	2,4-D + 2,4,5-T + fenac (.33:.33:.33)	Do.

# DETAILED PROCEDURES, RESULTS, AND DISCUSSION

## Ground-Applied Foliage Spray Herbicides

In 1962, ground applications of foliage spray herbicide treatments for controlling saltcedar were begun near Bernardo, N. Mex. These treatments tested applications of formulations of silvex and other phenoxy herbicides and chemicals for which effectiveness on saltcedar had not been established. Results (table 2) indicate that silvex controlled saltcedar most effectively, especially the emulsifiable acid and the ester formulations.

TABLE 2.--1962: Results of ground application of foliage spray herbicides for control of saltcedar, evaluated approximately 15 months after application

Date applied and chemical	Rate applied		Kill
	per acre, active ingredient		
	<u>Pounds</u>	<u>Percent</u>	
May 4, 1962:			
Atratone-----	10	0	
Do-----	20	0	
Prometone-----	10	0	
Do-----	20	0	
June 11, 1962:			
BE ester of silvex-----	2	8	
Do-----	4	25	
IO ester of dichlorprop-----	2	11	
Do-----	4	15	
OS amine of silvex-----	2	15	
Do-----	4	9	
OS amine of dichlorprop-----	2	8	
Do-----	4	14	
EA of silvex-----	2	15	
Do-----	4	43	
EA of dichlorprop-----	2	8	
Do-----	4	11	
PGBE esters of 2,4-D + 2,4,5-T (50:50)-----	2	4	
Do-----	4	10	
OS amines of 2,4-D + 2,4,5-T (50:50)-----	2	7	
Do-----	4	1	
Amine salts of 2,4-D + 2,4,5-T (50:50)-----	2	10	
Do-----	4	9	
July 3, 1962:			
Benzac 354-----	2	0	
Do-----	4	0	
Dicamba-----	2	0	
Do-----	4	0	

Dichlorprop was more effective than PGBE esters of 2,4-D + 2,4,5-T (50:50). Although herbicides in the s-triazine group had previously shown some effectiveness on hardwood species when applied in oil at early bud break,<sup>77</sup> atratone and prometone and the benzoics (Benzac 354 and dicamba) were not effective in these tests.

In treatments begun in 1963, also near Bernardo, N. Mex., compounds were screened for effectiveness, additives to silvex were evaluated, and high and low volumes of spray were compared. The only herbicide showing promise in these studies was Brushkiller 977 (table 3).

<sup>77</sup>/ Hunt, C. R., Geigy Chemical Corp., Yonkers, N.Y. Personal communication. 1962.

TABLE 3.--1963: Results of ground application of foliage spray herbicides for control of saltcedar, evaluated approximately 16 months after application

Date applied and chemical	Rate applied per acre, active ingredient		Kill
	Pounds	Percent	
May 27, 1963:			
2,3,6-TBA-----	4	0	
Benzac 354-----	4	0	
Dicamba-----	4	0	
Glytac-----	4	0	
Tritac-----	4	0	
June 6, 1963:			
Picloram-----	1/4	0	
Do-----	1/2	0	
Do-----	1	0	
June 12, 1963:			
BE ester of silvex-----	2	6	
Brushkiller 977-----	2	18	
62-255-----	2	8	
62-256-----	2-1/4	8	
62-257-----	2	2	
62-258-----	1-1/2	6	
July 3, 1963:			
Picloram-----	1/4	0	
Do-----	1/2	0	
Do-----	1	0	
July 31, 1963:			
Picloram-----	1/4	0	
Do-----	1/2	0	
Do-----	1	0	

In another treatment begun in 1963, varying rates of ammonium thiocyanate were added to the BE ester and OS amine of silvex (table 4). Results were so erratic that few conclusions could be drawn. Overall averages indicate that the addition of ammonium thiocyanate did not alter significantly the effectiveness of silvex, the OS amine of silvex was more effective than the BE ester of silvex, and 5 pounds of silvex was about 2.6 times more effective than 1 pound.

TABLE 4.--Results of applications of OS amine and BE ester formulations of silvex in combination with varying rates of ammonium thiocyanate on control of saltcedar<sup>1/</sup>

Silvex formulation <sup>2/</sup>	Rate applied per acre		Kill
	Silvex, acid equivalent	Ammonium thiocyanate, active ingredient	
	<u>Pounds</u>	<u>Pounds</u>	<u>Percent</u>
OS amine-----	1	0.005	5
Do-----	5	.005	7
BE ester-----	1	.005	2
Do-----	5	.005	8
OS amine-----	1	.025	10
Do-----	5	.025	9
BE ester-----	1	.025	2
Do-----	5	.025	8
OS amine-----	1	.125	1
Do-----	5	.125	6
BE ester-----	1	.125	1
Do-----	5	.125	8
OS amine-----	1	0	4
Do-----	5	0	14
BE ester-----	1	0	1
Do-----	5	0	8
OS amine <sup>3/</sup> -----	1	0	4
Do <sup>3/</sup> -----	5	0	8

<sup>1/</sup> Herbicide was applied on June 7, 1963. Kill was evaluated on September 16, 1964.

<sup>2/</sup> Carrier was water, except as noted.

<sup>3/</sup> Carrier was oil and water.

In another treatment begun in 1963, the effect of applying two spray volumes and two rates (ae/acre) of the PGBE esters of silvex was evaluated (table 5). Results indicated that the higher volume increased effectiveness of the herbicide at the lower acid equivalent rate but not at the higher acid equivalent rate.

TABLE 5.--Results of applications of two spray volumes and two rates of the PGBE ester of silvex on control of saltcedar<sup>1/</sup>

Volume in gallons	Rate applied per acre		Kill
	Acid equivalent		
	<u>Pounds</u>	<u>Percent</u>	
10	2	12	
80	2	21	
10	4	9	
80	4	11	

<sup>1/</sup> Herbicide was applied on June 18, 1963. Kill was evaluated on September 16, 1964.

#### Ground Application of Granular and Soil Spray Herbicides

Initial results of ground application of granular herbicides for control of saltcedar are shown in table 6, and initial results of ground application of soil spray herbicides are shown in table 7. For the 1962 treatments, a total of 7.05 inches of precipitation fell from the time the granular and soil spray herbicides were applied until kill evaluations were made. For the 1963 treatments, a total of 8.55 inches of precipitation fell.

TABLE 6.--Initial results of applications of granular herbicides for control of saltcedar, evaluated 16 months after application

Date applied and chemical	Rate applied per acre, active ingredient	Kill
	<u>Pounds</u>	<u>Percent</u>
April 16, 1962:		
Atraton-----	5	0
Do-----	20	0
Prometone-----	5	0
Do-----	20	0
2,3,6-TBA-----	5	3
Do-----	20	23
Fenac-----	5	0
Do-----	20	6
Fenuron-----	5	0
Do-----	20	2
Dicamba-----	5	66
Do-----	20	79

TABLE 6.--Initial results of applications of granular herbicides for control of saltcedar, evaluated 16 months after application--Continued

Date applied and chemical	Rate applied per acre, active ingredient	Kill
	<u>Pounds</u>	<u>Percent</u>
June 20, 1963:		
Prometone-----	5	0
Do-----	20	0
Atraton-----	5	0
Do-----	20	0
2,3,6-TBA-----	5	0
Do-----	20	13
Fenac-----	5	0
Do-----	20	0
Fenuron-----	5	0
Do-----	20	0
Dicamba-----	5	50
Do-----	10	77
Do-----	20	59
Picloram-----	5	15
Do-----	20	42
CIPC-----	5	0
Do-----	20	0
IPC + CIPC (50:50)-----	5	0
Do-----	20	0

TABLE 7.--Initial results of applications of soil spray herbicides for control of saltcedar, evaluated 16 months after application

Date applied and chemical	Rate applied per	Kill
	acre, active ingredient	
	<u>Pounds</u>	<u>Percent</u>
April 17, 1962:		
Fenac-----	5	0
Do-----	20	0
Isocil-----	5	0
Do-----	20	0
Monuron-----	5	0
Do-----	20	0

TABLE 7.--Initial results of applications of soil spray herbicides for control of saltcedar, evaluated 16 months after application--Continued

Date applied and chemical	Rate applied per acre, active ingredient	Kill
	<u>Pounds</u>	<u>Percent</u>
June 24, 1963:		
Fenac-----	5	0
Do-----	20	15
Isocil-----	5	0
Do-----	20	4
Bromocil-----	5	0
Do-----	20	0
Monuron-----	5	0
Do-----	20	0
Diuron + WK-----	5	0
Do-----	20	26

Results of the 1962 applications of granular herbicides show that dicamba was outstanding in its effect, even at the low rate; 2,3,6-TBA was moderately effective at the high rate only; all other applications were ineffective. Results of the 1963 applications show that dicamba was again quite effective and picloram somewhat less effective; applications of 2,3,6-TBA at the high rate killed a low percentage of plants; all other applications were ineffective.

Two years' research on control of saltcedar with soil spray herbicides indicate that fenac was only slightly effective and erratic; diuron with surfactant, in only 1 year's research, was more effective but did not kill a high percentage of plants; all other applications were ineffective.

#### Aerial Application of Foliage Spray Herbicides

Herbicides applied with a helicopter for control of saltcedar showed varying results (table 8). Applications in 1961 were apparently too late in the season to be effective. In 1962, very good results were obtained from all aerial applications of herbicide in Arizona, especially with PGBE ester of silvex and the 50:50 mixture of PGBE esters of 2,4-D and 2,4,5-T. The OS amine of silvex at the higher rate of application (ae/acre) and the IO ester of dichlorprop were about 10 percent less effective. Results of aerial applications in Texas in 1962 showed the same trends, although the overall results were inferior to those in Arizona. At the same rate of the silvex ester, the oil:water emulsion was more effective than the invert.<sup>8/</sup>

<sup>8/</sup> Water-in-oil emulsions that produce thick, viscous spray solutions.

TABLE 8.--1961 and 1962: Results of aerial application of herbicides for control of saltcedar, evaluated 16 months after application

Location, date applied, and chemical	Rate of application			
	Acid equivalent	Volume	Carrier	Kill
	<u>Pounds</u>	<u>Gallons</u>		<u>Percent</u>
<u>Bernardo, N. Mex.</u>				
September 1, 1961:				
Amine salt of 2,4-D-----	2	10	Water	0
Do-----	2	20	---do---	0
Amine salt of 2,4,5-T-----	2	10	---do---	0
Do-----	2	20	---do---	0
Amine salt of 2,4-D + 2,4,5-T-----	2	10	---do---	0
Do-----	2	20	---do---	0
Do-----	8	20	Invert	0
IO ester of 2,4,5-T-----	4	20	---do---	0
IO ester of 2,4,5-T + spreader sticker	4	20	---do---	5
<u>Buckeye, Ariz.</u>				
May 16, 1962:				
PGBE ester of silvex-----	4	10	Water	92
PGBE ester of 2,4-D + 2,4,5-T-----	4	10	---do---	92
IO ester of 2,4-DP-----	4	10	---do---	82
OS amine of silvex-----	2	10	---do---	57
Do-----	4	10	---do---	85
<u>Red Bluff, Tex.</u>				
July 16, 1962:				
PGBE ester of silvex-----	4	10	Oil:water	21
PGBE esters of 2,4-D + 2,4,5-T-----	4	10	---do---	20
IO ester of 2,4-DP-----	4	10	---do---	15
OS amine of silvex-----	4	10	Oil	13
IO ester of 2,4,5-T-----	4	10	Invert	3
EH ester of silvex-----	4	10	---do---	2

Results of the 1963 application of herbicides with a helicopter in Arizona were difficult to determine because a drop in the water table caused a death loss of about 30 percent on untreated plots (table 9). Plots treated in Oklahoma with a fixed-wing airplane in 1963 showed that the PGBE ester of silvex at the higher rate of application (ae/acre) reduced the stand 30 percent (table 9). The addition of ammonium thiocyanate to silvex at a lower rate of application appeared to increase the effectiveness of silvex at that rate but neither treatment was satisfactory as a single application. A mixture of the PGBE ester of 2,4-D + 2,4,5-T (50:50) at the higher rate of application was only slightly less effective.

TABLE 9.--1963: Results of aerial application of herbicides for control of saltcedar, evaluated 16 months after application

Location, date applied, and chemical	Rate of application		Carrier	Kill
	Acid equivalent	Volume		
	<u>Pounds</u>	<u>Gallons</u>		<u>Percent</u>
<u>Buckeye, Ariz.</u>				
May 24, 1963:				
BE ester of silvex-----	4	10	Water	$\frac{1}{70}$
OS amine of silvex-----	4	10	---do---	$\frac{1}{50}$
<u>Hardesty, Okla.</u>				
May 28, 1963:				
PGBE ester of silvex-----	4	5	Oil:water	30
PGBE ester of silvex + 1% X-77-----	2	5	---do---	13
PGBE ester of silvex + .025 lb. ammonium thiocyanate/acre.	2	5	---do---	26
PGBE ester of silvex-----	2	5	---do---	17
PGBE ester of 2,4-D + 2,4,5-T (50:50)	4	5	---do---	24
PGBE ester of 2,4-D + 2,4,5-T (50:50)	2	5	---do---	23
PGBE ester of 2,4-D + 2,4,5-T (50:50) + 1% X-77	2	5	Oil:water	17
PGBE ester of 2,4-D + 2,4,5-T (50:50) + .025 lb. ammonium thiocyanate/acre.	2	5	---do---	33
<u>Red Bluff, Tex.</u>				
June 3, 1963:				
IO ester of silvex-----	4	8	Oil:water	0
OS amine of silvex-----	2	16	---do---	0
IO ester of 2,4-DP-----	4	8	---do---	0

TABLE 9.--1963: Results of aerial application of herbicides for control of saltcedar, evaluated 16 months after application--Continued

Location date applied, and chemical	Rate of application			
	Acid equivalent	Volume	Carrier	Kill
	<u>Pounds</u>	<u>Gallons</u>		<u>Percent</u>
OS amine of 2,4-DP-----	2	16	Oil:water	0
OS amine of silvex-----	2	16	Invert	0
IO ester of 2,4-DP-----	4	8	---do---	0
OS amine of 2,4-DP-----	2	16	---do---	0
Do-----	1	8	---do---	0
OS amine of 2,4-D + 2,4,5-T (75:25)--	2	16	---do---	0
Do-----	1	8	---do---	0
OS amine of 2,4-D-----	2	16	---do---	0
OS amine of 2,4,5-T-----	2	16	---do---	0
Do-----	1	8	---do---	0

1/ A drop in the water table was responsible for about 30 percent loss on untreated areas. This loss was not subtracted from these figures.

#### SUMMARY

Results of research on ground application of foliage spray herbicides from 1961 to 1963 for control of saltcedar show that, of all herbicides tested, the ester and emulsifiable acid formulations of silvex were best, although results were erratic. Addition of ammonium thiocyanate at the rates of 0.005, 0.025, and 0.125 pound ai/acre did not increase the effectiveness of silvex. A higher percentage of plants was killed at the lower rate of 2 pounds ae/acre of the PGBE ester of silvex when the spray volume was increased from 10 to 80 gallons per acre. Applications made at the rate of 4 pounds ae/acre apparently were not affected by the greater spray volume.

Only one application of granular herbicide applied in 1962 appeared to be effective on saltcedar. Rates of 5 and 20 pounds ai/acre application of dicamba reduced the stand 66 and 79 percent, respectively. In 1963, dicamba was again the most effective granular herbicide, with 50-, 77-, and 59-percent kill at the rates of 5, 10, and 20 pounds ai/acre treatments, respectively. Picloram, at a rate of 20 pounds ai/acre, reduced the stand 42 percent. All other granular herbicides were relatively ineffective.

A soil spray application of diuron, with a surfactant (WK) at the rate of 20 pounds ai/acre, resulted in a 26-percent plant kill. All other applications were ineffective.

Results from aerial application of herbicides in Arizona, New Mexico, Oklahoma, and Texas from 1961 to 1963 showed that the PGBE ester of silvex and the PGBE esters of 2,4-D + 2,4,5-T (50:50) at a rate of 4 pounds ae/acre were the most effective herbicides tested. A comparison of oil:water emulsion and invert showed an advantage for the oil:water emulsion in Texas. Addition of ammonium thiocyanate appeared to increase the effectiveness of the lower rates of herbicide in Oklahoma.

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